Address

by

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Milam Auditorium
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INTRODUCTION

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Dr. Fuller has received 43 honorary doctorate degrees in arts, letters, architecture, engineering, humanities, laws, fine arts, and engineering design. He has been honored by over twenty learned societies of world stature. One of these is of particular meaning to me, for in 1960 Dr. Fuller was awarded the Benjamin Franklin Fellowship of the Royal Society of Arts of London, perhaps the most prestigious of all of his international credentials.

Dr. Fuller has managed to keep ahead of his biographers, ten in number to date, by just completing or being in the process of completing his own twentieth book. He has traveled and studied, and I emphasize both of these words, around the world 47 times. He has produced over 200,000 structures, structures that are dedicated to the housing of the world's needs. In his view, the arts and the humanities, the sciences and the various branches of technology, are one and inseparable. If one reads through the catalogue of this university, as I did this afternoon, one can very easily project an image, a creation of Buckminster Fuller, into the mind's eye of every single school, every college, every research institute on this campus.

He is particularly concerned with the humanity of man, and I might add in this context, especially with the university focus as it should be, that he is far less concerned with those aspects of university life which we summarize in such terms as FTE and GPA. He is less interested in what he would call "interdepartmental communication" than what he would call "interdisciplinary gymnastics." That is to say, he is interested less in the interplay of faculties than the entertainment of creative ideas.

In the final analysis, therefore, we have a man who has dealt for over fifty years of his creative life, and he reaches us this evening at the very ripe and glorious age of 85, more in terms of interaction than interdisciplinary exchange, and I suppose that in the final analysis his works lead to something that may be likened to a kind of mystical transaction in which the thoughts of man, historic and certainly contemporary, are brought together for something that we would liken to a world view.

This indeed is his subject this evening--not the geodesic dome, as was published in the Barometer--a world view that comes to us through the aegis of the University Convocations and Lectures series, one which gives me great pleasure to introduce to you our distinguished speaker this evening. There will be slides shown. I realize that we do have some problems of physical discomfort and I salute the standing audience and assume that they are all students in good standing. Dr. Fuller---

I have to always un-introduce myself. I am 85, and I don't know how well any of us will know what we really are, but I'm really confident that the only thing important about me is that I am a healthy, average human being. I'm absolutely convinced that there's nothing I've done that others couldn't have done equally well or better. I'm convinced that the only reason I have this record is because I deliberately undertook an experiment 53 years ago at the age of 32 which involved my carrying on in a way that most people don't realize you can carry on today. I undertook at the age of 32 to make an experiment to see what, if anything, a little, unknown, penniless human being with a wife and a newborn child might be able to do effectively on behalf of all humanity that would be inherently impossible for great nations or great private enterprise to do. It's perfectly clear to me that with three-fourths of the world covered with water, of the 29% which is dry land, more than half of that covered with snow and ice and rocks, only about one-eighth of the surface of the earth is propitious for the support of human life, and that's not all in one piece. It's in very many little pieces. Humanity finds those propitious points and struggles to survive, guarding those spots, because they often find themselves being invaded by others who have not been so fortunate. Our nations have really been preoccupied with very small proportions--I'm taking one-eighth of the surface of the earth and dividing it up into over 100 nations--so that the total land perogative of any nation is really very small--and they don't think in terms of the world even though they teach geography about it. They're not concerned as a nation with the whole world. I saw private enterprise represented bets, and when they put up so much in bets within a pretty short time they go bust. They were very shortsighted inherently. So I saw that there was nothing to stop me as a little individual from looking at the total planet earth as a spaceship which it really is--after a while I call it the Spaceship Earth--and looking at the total resources, the total cumulative know-how, and being concerned with how they applied the total know-how and the total resources to work for everyone.

So I've been engaged for over half a century in really looking always at the total planet, total people, total resources, never limiting myself at all to thinking in the national kind of way since I had no competition. That's the only reason you know about me. And I really want you to realize that, *that* I am quite amazed at the kind of productivity that a little individual can demonstrate if you really are free. I said that I was penniless, and I said that I was 32 when I started this. Life expectancy for someone born when I was was 42, so I theoretically only had ten years to go. And I obviously wouldn't get anywhere trying to ask three billion people to listen to me, because that's when people don't listen. So I assumed that I wouldn't get anywhere just by talking and asking people to listen. I said what is very, very evident is that you and I were designed in a very delicate manner. I don't know how used you are to thinking about the design of yourself as a structural problem or a mechanical problem, but you and I are 60% water and that water isn't just reserve drinking water.

In nature you have triple bonding, three points, and you get what is called rigidity. With two bonds you have a hinge. You have a single bond and you have a universal joint. With triple bonds, you have much more tension

because you have three times the holding. With this you have only two times the holding. The point is that two, which is a hinge, distributes loads. Three points is rigid and doesn't distribute loads. For all the building that human beings do, we try to build rigidly and we don't have a very good distribution of loads. But with the pneumatic tie-in, the automobile, we do have the pneumatics distributing their loads, being universal jointed. And they distribute their loads to the full tensions casing, which makes it very much more powerful, so you can have enormous loads on that little automobile tie-in.

So I see that in human beings and in all the biology nature uses crystallines producing fibers to give it maximum tensile strength. But compressively we are entirely liquids. Liquids distribute their loads, and liquids have another extraordinary property of being non-compressible, so you can take a hydrolic jack and lift a whole building with it. We're designed with hydrolic compression in counter-distinction with the way we build our buildings, which are rigid. And because I do have hydrolic compression like that I am 85 and the loads keep getting distributed all the time. This is why with a great tree--if you tried to hold two weights out sideways like two suitcases you would have a very difficult time. We do find tree after tree with a main root not much bigger than your shoulder holding maybe two to three hundred pounds out there sideways, and some getting as many branches as four to five tons out there. All because it is liquid. And if you freeze that tree, it can't distribute as well and off comes the branch.

So I want you to understand what I said, that human beings were designed in this rather unique manner, with liquid compression. Liquid boils and freezes at very small limits, so you and I couldn't exist in any excepting our own biosphere. We don't know any other planet of this particular kind or condition, so we were designed very specifically for this particular planet. As clear as can be 53 years ago, I saw that if I wanted to be effective on behalf of human beings I might be able to do so by concentrating on producing artifacts that would make the human environment more favorable, giving humanity a chance to behave more thoughtfully towards one another.

At any rate, I committed myself then to developing artifacts and particularly to taking the most advanced science and technology which have been going primarily into the world of weaponry, and applying the most advanced science and technology to environment controlling for humanity to give them a better opportunity to cope with and get on with the universe. I'd like really quite quickly to say, because my time has been cut way down by what has been going on, that I am dealing with what I'm sure is the very essence of the problems of the humans onboard of our planet right now, that humanity is in a great crisis, and I do have a lot of knowledge about what can be done in the way of design revolution to possibly make all of humanity a success.

The first thing I began to consider then 53 years ago was, actually, number one was I was going to be committed to producing artifacts. If I was going to use all kinds of materials, if I was going to use tools, and have other technical people working, obviously I would need a lot of money or something equivalent to it. I didn't have anybody who thought what I was concerned with was worth doing. I didn't have any authority to tell me to do what I was doing, and as I said I was penniless. So then I had to do some thinking about whether it was feasible for me to carry on in this kind of way. My reasoning went as follows.

In the first place, I assumed that human beings must have some very important function to perform in the universe. The reason I say that is this. We think about human beings in counter-distinction to all other living organisms and find that all the other living organisms have some built-in integral organic equipment to give them special advantage in some special environment. A little vine that just grows up the Amazon and no place else has exactly the right equipment for it. I saw then that human beings were not unique having brains; many creatures had brains. The brains are always and only coordinating the information from our senses--the smelling, the touching, the seeing, the hearing--only by virtue of which we know we are alive. Incidentally, we have such extraordinary sensing equipment, particularly the seeing, that we have a television set that has no frames, so you don't have a show going on and then something called "reality" going on outside the frames. We have unidirectional, completely frameless television. No human being has ever seen outside of their brain. All the seeing is actually being done in a little television studio inside of you. As a little child you see this over there and you go over and touch it. A child has to keep touching everything to be sure that his eyes are really working, till we finally convince ourselves we're seeing things outside of ourselves. At any rate, my point is that our brains are always and only coordinating this special information of our senses. This one smells a little different from that, so each one of these has special case experiences. We are able then to memorize those and recall them for various reconsiderations.

In counter-distinction to this brain that is always dealing with these special cases of the senses, everything we call "reality," we have the human mind. The human mind has the capability from time to time to discover relationships existing between special cases that are not in any way discoverable by considering the special cases one by one.

I'm going to take you very quickly to the very extraordinary experience human beings have had through all history of the great skies, with all these constellations. Humanity used to think of them and speak of them as fixed stars, in counter-distinction to which sometimes one, sometimes two, sometimes three little bit brighter lights would appear in the sky in front of this constellation for a little while and then that constellation, so that they were clearly moving. We called those the planets. Humanity, then, was very deeply impressed with these moving items in the sky in counter-distinction to the fixed ones and gave them names of gods and tried to identify their appearances with various experiences in our lives. But not until we get to calculating capability with the positioning of numbers do we come to the point where Copernicus with his data was able to demonstrate quite clearly that the sun was <u>not</u> going around us, but that we were one of the planets going around the sun. This excited other scientists, and [TYCO BRAHE?] in particular, a man of very great means, acquired very much better observational instruments, but he was not a mathematician. He got Kepler to work with him on his beautiful instruments. Kepler found that these planets were all different sizes, they were all different distances from the sun, they were all going around the sun at different rates, so if they were on the same team they seemed to be very disorderly. But he said, as a mathematician, at least they have one thing in common. At least they're all going around the sun. As a mathematician I can give them something else in common. As I remember, he gave them exactly

twenty-one days to go around the sun each; they had exactly the same amount of time. Now see what each one does with the same amount of time--not just overlap, the same amount of time. He sighted each one at the beginning of twenty-one days. He made a little diagram with scaled lines---how far this one was from the sun at the start of the twenty-one days, and what angle it would go from the sun. Then at the end of the twenty-one days, he started a second line from the sun. This gave him a long thin diagram for each one of them. Then he filled in the arch. Now he has these triangular areas and he said, I might as well calculate the areas because that's why I gave them this common mathematics, hoping to find something more out.

If you were Kepler and had kept on making the calculations and discovering that they were not similar, but they were exactly, elegantly exactly the same mathematical areas, imagine how startled you really would be. Quite clearly, despite the seeming disorderliness they were obviously coordinating. This is a product of extraordinary--sweeping out the same area in the same amount of time in the sky. To be able to coordinate like that, and they are millions of miles apart!

If I have a weight on a string swinging around my head and if I let go of it it goes off in a line. If the thread breaks, it's going to go out in a line. He said, here are these things out there coordinating, quite clearly they're doing it in orbit. And quite clearly, he said, I know if I want to make an ellipse, I have to have two restraints. I can see that because they're different distances from the sun, there are times when they bunch together. Therefore, it's something to do with their bunched mass that seems to pull evenly. I'm going to assume that there is a tension with no cross section at all, so powerful that it can hold, work, operate over millions of miles.

I want you to understand how different this is from anything we can perceive. Here's a human mind discovering a relationship that is completely invisible, nothing to do with the sense visible. Outside of the data he had accumulated. This is the difference in the human mind and we don't know any other phenomenon in the universe that has the capability from time to time to discover relationships existing that are not manifested by any of the special cases considered separately.

Incidentally, that is also a definition of what is called "synergy," the behavior of the whole system unpredicted by the behavior of any of the parts considered only separately. It goes on with Galileo measuring what are called "falling bodies." It is an envy when you realize that there is no "up" and "down" in the universe, that you also can't fall, so that the word "falling body" which Newton really differentiated out from what he saw, he was dealing with a great generalized case against something very local, this "falling bodies" and the concept of no "up" and "down." It was simply the same thing, but a very, very small selection of bodies and a very large selection of bodies. At any rate, Galileo found that his rate of falling was acceleration as a second power, analogous to the distance traveled. And out of this comes Newton formulating his mass and attraction of celestial bodies, where we say that the inter-attractiveness generated between any two inversely is the second power of the mathematical distance intervening. Here, then, are these extraordinary inter-relationships discovered by the mind that can only be expressed mathematically, which is a completely intellectual phenomenon.

Now we have what is called a "scientific generalization." A scientific generalization can't qualify as such if there are any exceptions. When I say something has no exceptions, it's inherently eternal. We're talking about the human mind dealing with the eternal versus the brain dealing always with the temporal, the things that begin and end. The beginning and the end of the universe, the mind doesn't deal in that.

So, I want to get back to the outset, when I said to you apparently humans must have some very important function to perform in the universe, to have been given this access to the great laws of the design of the universe itself. That we would have discovered none of these generalized principles--none of them has ever been found to contradict any of the others. When you and I use the word "design" we immediately infer an intellect sorting things out and arranging in preferred ways. Quite clearly, the fact that none of the generalized principles has been found to contradict one another, they're all eternal, means they're all cooperative and not contradicting. Many of them augmenting one another would indicate that we have a very extraordinary intellectual design of a universe. And that humans were invented to that must mean that we have some very important function to perform.

Yet in a universe that could design a human eye, that could design, as I spoke about, this extraordinary hydrolic compressioning of ours, design a brain--we have a little idea what the brains look like today, but we wouldn't know how to make them self-regenerative--in all the extraordinary design of the universe itself, you and I were deliberately designed to be born naked with beautiful equipment, but with no experience whatsoever. We're absolutely ignorant. We were designed to born ignorant, and yet we're given hunger and thirst, and curiosity, procreative urge after a while, to force us to learn by trial and error. This seems to be a very deliberate piece of design. Assuming, then, that we have some very important function within the universe eventually to perform for which we're given access to the great design laws of the universe itself, yet being designed naked, helpless, having to learn by trial and error means that it was a long time before human beings even knew what was safe to eat. It took a long time to get words to tell one another what you could eat, what was safe. It took a vastly longer time before we could learn how to write those words so that the dead could speak to the living about what they had learned. But we've been integrating our information for a long, long time and we're now, in my estimate, my working assumption, at a new point where we've come with enough knowledge. There is enough communication capability between all of human beings. Having been around the world 47 times myself, I really know that is so. I've been a guest at over 550 universities around the world, colleges, and there is an extraordinary general comprehension of what is going on and everybody has an idea pretty much about a total world, though there are many political governments that interfere one way or another. But as far as human beings go we are all in a very advanced state of being able to communicate with one another which did not exist when I was young.

The next thing I'd like to point out to you is, as I told you, I had this challenge of how was I going to carry on if things are going to cost a lot of money, this and that, and I didn't have any, and there was no one there to help me carry on. I then said to myself, the fact that the human mind does have access to these and does have some important function to perform, the fact is

that in order to learn, after being born naked, we're going to have to have a whole lot of energy to grow. We're going to have to have a whole lot of energy to operate. And human beings like other mammals can't take a sun bath and get enough energy from the sun to keep growing. So I said, all the vegetation was designed to be rooted and to expose an enormous amount of leafage in order to be able to get enough sun and by photosynthesis to convert it into beautiful hydrocarbon molecules, which other creatures began to eat, proliferate and make many more hydrocarbon molecules.

Incidentally, being completely anti-entropic up to this century, we have a really very powerful effect on the academic world of the great second law of thermodynamics, that every system is running down, losing energy and giving off energy in an increasingly disorderly manner. We found that on our planet, here on earth, is one place where the random receipts of the sun and other stars (when there are no clouds in the way) are being converted to beautiful ordinary molecular structures, completely anti-entropic. We are the great anti-entropic center, the only one we know about. We wouldn't be able to know about any of the others because where energies are being imported they give off nothing. The only reason we see all those stars is they're doing the exporting. Because they are all loci, there had to be a time when energy had been collected at those points, so we are apparently one of those points in the universe where energy is being collected in a very orderly way, stored against becoming a star sometime.

Anyway, here we are onboard that planet and needing an anormous amount of energy and the vegetation is providing it for us. Because vegetation is rooted, it can't reach the other vegetation to appropriate it, so the whole system would break down if it weren't for nature having created all the mobile creatures. Whether they are flying insects or crawling or just going as worms below the surface, the traffic back and forth between all the botanicals cross-fertilizes them to keep them regenerating. Nature doesn't say to the honey bee, why don't you go out and cross-pollenize. Simply, it gives the honey bee a drive to go after honey and, inadvertently, at 90 degrees it knocks off the pollen. All these creatures, then, operate inadvertently at 90 degrees to correspond and make the system work. So what we call "ecology" is a system of inadvertency with the actual DNA, RNA programming being designed to go after something and inadvertently at 90 degrees to do this other. When things happen at 90 degrees this way, I call this "precessional" in very much the same way that the effect of other bodies in motion is precessional. The gravitational pull of the sun on the earth makes the earth go at 90 degrees in orbit, not to fall into the sun. This is typical of other precessional effects, all a regenerative system is.

I observe, then, that human beings, being born naked, helpless, ignorant, gradually learning to domesticate animals and so forth, getting to the point where there is one man who has a milk cow he's been breeding and he has some kids that want some shoes, and another man has learned how to take cowhides and make shoes. And the cowhide shoemaker has some kids who want some milk. So here's the man owning the cow and he wants some pairs of shoes for his kids, and they agree that you can't cut up the cow and still milk it. So that's when they invented money, some kind of way to represent the amount of time that each one had invested in producing his particular product. Making shoes must have

less time involved than developing a milk cow. So human beings are sort of honey-money bees. Everyone's sort of honey-money beeing out here trying to look out for their children, and at 90 degrees doing some of the right things for the wrong reasons.

In the military game, a great leader of any nation wants to develop his defense. He has a military side and the military side says, we're going to have a war and we're going to have to use these extraordinary new weapons. The politicians say, we can't afford those. So the military says, buy or die. So the politicians say, do we know how to make them? And they say, yeah we know how to make them. Go ahead and make them, then, never mind what they cost.

So we find that only when it's something to do with a group struggling do we have society actually undertaking very extraordinary new technology. And out of the extraordinary new technology inadvertently comes fallout into the home economy after a while, because all the money going into the new weaponry doesn't go into the weapons themselves. It has to go into instruments and tools that make tools. In fact, a very large production center could just as well be making lamps as making weapons. So that after the contracts terminate because a weapon has become obsolete, then you have those industries looking around the home market for some outlet. We have about a generation later a fallout into our economy of technology which makes it possible to take care of more people with the same amount of energy or material.

I came to the point, I'll give you a little bit of an idea, where I said, all right, I see then that in nature all these creatures are doing these things and inadvertently doing the right things for the wrong reasons; going out to war and getting a technology. It says way back in the Bible you should turn the swords into plowshares. There is that kind of a fallout. And life has been changing and advancing very rapidly by virtue of that technology. So I said, supposing then that instead of my going out to honey and money I just commit myself to doing what nature wants--now I'm assuming that human beings are very important and nature wants us here. She has to take us through a certain cultivation period of trial and error to learn that our minds are everything and our muscle is nothing. At the present time muscle and cunning and fear are in control of the world. I said, I'd like to get to where my mind is really operating, where we're making some very, very different decisions.

So nature, then, gave us enough cushion of trial and error to get us to the point where we will learn to really operate with our minds, to really go on what the truth might be and examine things in terms of everybody instead of just a few. I said that supposing then I assume that you and I are here for this ultimate function of our mind and are given access to the great design of the universe to probably very much--for instance, I said, I'm going to make a working assumption that we're here for local universe information gathering. By learning about these principles with our minds, we learn about optics, we learn about how to make a microscope and a telescope. We're able to get an enormous amount of local universe information. And what is common to all lives and all histories--problems, problems, problems. If you're any good at problem-solving you don't come to utopia; you come to much more difficult problems to solve.

We're here, quite clearly, as I say, for information gathering and local problem-solving in support of the overall greatest thing we know about the universe, which is that the universe is eternally regenerative. We are here, then, as a local function in support of the integrity of an eternally regenerative universe. By being given some of the great design roles themselves, we are able to tackle things in a very, very big way, but we would have to mature very much before we would qualify to behave that way. But I can see we've been moving forward very rapidly with really an exponential rate of gain of information and communication capability between the human beings themselves.

When I was young, incidentally, my first job was before World War I. I worked with some very skillful workmen, very fine human beings, but their vocabularies were approximately 100 words, 50% blasphemous and obscene. They mainly spit to let you know how they felt about you. This completely changed. Humanity suddenly really does have communication capability with one another in this extraordinary manner all around the world. We can reach each other to do that today. We can reach each other anywhere around the world, so that there are completely new and different stories coming in.

So I'm assuming that we're coming to some threshold where we may be qualified to function the way we're ultimately supposed to. Suppose, then, I were to commit myself to making human beings a physical success. To do more with less, and so forth. To do so most economically, because nature always acts most economically. If I would commit myself then to developing environment control for humanity, developing artifacts and so forth that would greatly enhance the probable success of human beings, it could be that I'd find myself getting on all right. In other words, I would not have to do the right thing for the wrong reason, I could do the right thing for the right reason. I said, supposing I make an experiment of doing that. It would be very interesting to see. I see that hydrogen atom doesn't have any trouble behaving like a hydrogen atom. So I said, I'm going to try out this experiment, as I did 53 years ago. But if I'm doing what I'm supposed to really be doing in the direction of making humans really a success so that they can function with their minds while trying to get on, this meant being very, very sensitive about what I ought to be doing, and I had to have alternate things so that when time and again I found things weren't going well I could change my course, and then I seemed to be doing just the right thing. That's 53 years ago and I have been able to get on since that time. I've been able to increase the magnitude of my initiative-taking and what is called "design revolution."

So for the last quarter of a century, my average expenditure annually of what I undertake to do is over $250,000. And I don't have any way of knowing that that is coming in because I don't allow--like nature has its own gestation rate--I don't allow anybody to promote, I don't have any public relations or any agencies getting lectures. I must have nothing of that kind. I mustn't have anybody in my office ever soliciting any support of any kind whatsoever. I must never ask anybody for help. And I must simply go wrong the way certain senses allow me. But I've been able to expand this to about a $250,000 operation and I do get my bills paid, simply because no sooner do I undertake something then somebody will ask me to speak over here and will pay me enough to pay a big share of my overhead, whatever it may be. So I really believe it is almost a complete miracle. The very fact that I've been able to do the things that

were reported in the introduction is because I've been absolutely and utterly free for 53 years from any idea of earning a living. Starting with absolutely nothing, but being very sensitive to whether things are going right or wrong and recognizing error very, very quickly. It's like you're an explorer. You don't have any maps or charts to go on; you have to make your own soundings all the time. I wanted to get that one out of the way.

The next thing I want to point out to you--I've said that if I'm going to do my own thinking, which I was doing, I'm going to go entirely on experimental evidence. I'm going to operate very strictly on experimental evidence, and I'm going to have to really dare to go along with experimental evidence, whatever it says. This means also giving up everything I've ever been taught to believe, anything such as loyalty and so forth. I'm really doing my own thinking here, of what the values are. One of the things I've observed in my life is that a very large number of human beings have an intuitive feeling that there is some greater wisdom, something, if you want to call it God, that is operating. And I said to myself, do you have any reason personally in your own experience to have to assume a greater intellect than that of human beings to be operating in our universe? Luckily, I'd had very good scientific training by which I could talk as I've been talking to you already about discovering a generalized principle. I'm just overwhelmed by the manifestation that you can only state these generalized principles mathematically, which is purely intellectual. There is an internal integrity manifest here. I'm overwhelmed by--if you want to call it--God. I'm just absolutely overwhelmed. Therefore, I'm going to commit myself in absolute faith to God. If I do what God is trying to do in the universe--and I'm not talking about a "man-God," I'm talking about an intellectual integrity, a designing capability--if I'm doing what ought to be done I'll get on. But I must do this in absolute faith. And I have had that absolute faith for those years. I assure you, being human, I've made many mistakes. I've weakened, but I've gone on that entirely.

Now. The next hing I would like to do with you is to, as quickly as possible, having committed myself to what I call a "design revolution," to take the most advanced science and technology and apply it immediately to what are called "livingry" instead of "weaponry."

When I was young, reality was everything you could see, smell, touch, and hear--very, very clearly. That is, everything the brain was dealing with. The year I was born, the x-ray was discovered. The year I was born Marconi discovered theoretical wireless. We didn't actually have s.o.s. until I was twelve, but there it was. When I was three years of age, the electron was isolated. And we have, then, a whole new visible world coming in. Wireless--you can't see them! I came into a very new era where the sensorial reality--where we're coming into a non-sensorial reality. And in my century we had the experience of, actually that leads us to work with finding chemical elements incandescent in an arc flame giving off light, which light, going through a prism, gives off the light into spectral lines which you and I can't see but the chemical emulsion of photography can see. So then we began to discover that each of the chemical elements, this is this century, each had its own unique frequencies and wavelengths, absolutely unique to them. This is completely invisible reality.

By 1930 we had the first chart ever published of the great electromagnetic spectrum. And on that chart we start with mile-long radio waves that during

World War I were used, getting shorter and shorter until finally getting into the infrared, then red, yellow, green, blue, violet, where you and I've been given the equipment to tune in, and then ultraviolet on out. As of 1930 we've discovered that where human beings can tune into reality is only less than a millionth of reality. It is a complete jump. But because it is an invisible reality society in general didn't really feel this, didn't realize we'd gone into an invisible reality. I'd like to point out today that 99.9999% of anything that is going to affect all of your lives tomorrow is being conducted in the realm of reality non-directly contactable by the human senses. For this reason we are really extraordinarily blind to what is going on around us.

I became fascinated in World War I, as a regular United States line naval officer, that everything we knew about the science of technology that we could transfer into technology we had onboard our ship. We had an enormous amount of power to operate it. But everything in the navy was leading up to moments of contact with the enemy and destruction. Everything was leading to destruction. All the highest capability known to humanity focused continually on destruction. Can I find out any really very good reason this is true?

It all went back very rapidly in the following manner. I've pointed out to you historically that all the great empires, whether it's Genghis Khan or the Roman Empire-- All of you in history, who know your history at all know that there was a time up to 200 B.C., between 400 and 200 B.C. when the Greeks were extraordinary in their advances of thinking and discovering, that we really did have a solar system and even probably a number of solar systems. We have that sunny orb and we have that diameter or the circumference of the earth very accurately measured by 200 B.C., the first globe of the earth. Very clearly, this notion about spherical earth. But by then we have with the Roman Empire a very deliberate development of what we call the Dark Ages, when we give up all that concept. The deliberate destroying of the library at Alexandria-- it took three different emperors, centuries apart, to finally get that knocked down. But the development of the Dark Ages is very, very important when we realize that they did happen and it was such a retrogression in fundamental thinking. We have the Roman emperor, physically very strong, but his strength belittled by something else that had happened in a very big way.

Going back as far as we can in our communications history, written history, say, 8,000 years ago with the time of the pharoahs, life expectancy was probably about nineteen years of age. And that is why you'd have an Alexander the Great doing so much at just sixteen. Like the young athletic scene, with the facts of life, that was all that seemed to matter. Life was so tortuous that nobody thought of this life being worthwhile from a common point of view, and would hopefully get qualified to get into the next world. But because your experience is such that only the pharoah gets in on anything, the food and all, you hope that the pharoah could get into the next world and then, you being his people, he could get you over there with him. So we have the society organizing very tightly to develop the pyramid, because there was such vandalism, such want, that nothing was very safe from stealing. You had to get the pharoah over into the next world with all the things he needed so you have to have this enormous stone pile, and they built the pyramid that way.

We have, then, the designing of the pyramid where we get all those blocks of stone elevated. We have a man who has really a very brilliant engineering mind and he realizes that you could take stone blocks--in the first place, you could shovel the earth and rocks and sand and make a hill, a rather easy, sloping hill to keep going around your building of stone. And if you put two wooden rods as tracks and then you add rolling logs with stones on top of them, then you had levers moving these stones to get them to the elevation where they were going to go. So you have the principle inventing of leverage and using the rolling device and so forth.

Finally, that pyramid gets built and the pharoah dies and gets over to the next world, hopefully. They put the designer there into the tomb with him as a reward so he'd get over into the next world a little quicker. Then there's the next pharoah to be thinking of, and in order to get him over into the next world you have to do these things in this world. So everybody remembers about the levers, you don't have to re-invent the lever. You don't have to re-invent those logs that you roll with and so forth. But the next designer sees his workers are dying of starvation, and he sees that wherever the Nile is touching the land is green; the rest is just desert. So he invents irrigation ditches. In this way, a tremendous amount of work gets done simply because all the workers are not dying of starvation so fast.

One after another pharoah dies, but that leaves some know-how in this world as he gets into the next world. So there is cumulative technological know-how in this world. There finally gets to be so much technological know-how that not only can we get the pharoah into the next world, but we can get the nobles in, too. So the nobles get in and that means they're building many more of these same kinds of great tombs and the technology keeps increasing in this world. Finally, they get so much technology that they can take care of the pharoahs, and the nobles, and all the rich middle-class. That brings us into the Greek and the Roman times, where you get the rich middle-class getting their very fancy mausoleums. Finally, there is so much accumulation of technology that you get to where Buddha, 600 years later Christ, and then Mohammed said, everybody gets into the next world. This is an extraordinary new moment! But then you have the priesthood which is all the time telling you what you have to do to qualify to get in. You can get in all right, but you're going to have to do a lot of things that I tell you to do. So we found that the priesthood was very, very powerful and the Roman emperors found themselves up against the very great power of the priesthood about what you have to do to get into the next world. The emperor, then, took over the papacy and took over authority all the way from the son of God. They had it. So then they said, if we're going to really be the authority about how you get into heaven, we're going to have to get over this nonsense that we're going around the sun. We're going to have to have the sun going around us. We're the center of things. We're going to have a nice flat earth. We're going to have an absolutely flat earth because now I'm going to tell people they're either going to ascend into heaven or go down into hell. I have to have a flat plane to do that. I can't have a sphere. All of our x, y, z coordinates and all of those things, incidentally, came from that flat earth, that kind of a concept.

We're still overwhelmed by that, despite the fact of Copernicus, despite the fact of Galileo. I'm sure that everybody in this room uses the words "up"

and "down." Anybody who doesn't? Okay. There is no up and down in the universe; it is absolutely meaningless. It came out of the Dark Ages. The fact that we really know some of these facts that I'm talking about, and we know them very well, but we don't do anything with them in our educational system is, to me, really very chocking.

I was asked in 1953 to give the monthly address of the Faculty Club of Massachusetts Institute of Technology. I said, any of you scientists present who do not see the sun going down in the evening, please show hands. There were no hands. I said, I'm absolutely shocked to be talking to such ignorant people. We've known for 500 years that the sun isn't going down and you deliberately tell your own children to look at the sun go down! Do you consider the fact of the matter, that you're deceiving your own children? You call yourselves educated? Really! Wow!

So I began then to get into my studies of what is really going on in history, trying to understand how we came to destruction. I point out to you that we had the calculated capability made possible with Copernicus, where the positioning of numbers came in, which also made possible navigation. Through that navigation Magellan was able to get around the sphere and demonstrate that we are in a sphere. So it got into the public domain that we are on a sphere.

I'd like to point out another couple of very powerful pattern changes in the history of humanity. We had the Orient developing long, long before Europe with enormous riches. Caravaning was coming from the Orient over the Sinkiang and so forth and Khyber Pass, etc., etc., and finally crossing the Bosphorus and getting into Europe. Caravaning animals. In the meantime, human beings were getting on the water more and more, and ship building was moving and improving. I want you to think about just a ship. With two waves under its bow and stern, it's a beam. The next minute a wave is in the middle of it and it's a cantilever. Waves do this to a ship all the time, and the engineering had to move very, very powerfully on the sea in order to cope. Finally, they learned how to make big ribbed ships, or keel ships, following the backbone of the whale and the backbone of the human being with the ribs at 90 degrees to it. They finally got some very powerful ships. And about the time of Crete, 1400 B.C. to 2000 B.C., we have the Phoenicians developing. I think they built their ships in the Indian Ocean but they finally got them into the eastern end of the Mediterranean and the Aegean Sea.

Suddenly, something else happens, because along those caravan trails we had places where trails came together and city-states developed with very powerful walls to guard the wealth of the trade that was involved. And we had also city-states commanding very fertile valleys, just like Mycenae. The thing about Mycenae is it's run around by hills, a very fertile valley, but in the middle of it there is a hill not quite so high with a well at the bottom of it, luckily. You build walls up around the top of the crown and then walls down to your well and enormous grain bins inside, and when you see the enemy coming through the passes you put all the food inside and you scorch the fields so they have nothing to eat outside. The enemy arrives and needs food, and can only go about thirty days without getting very weak for food. The people

inside had all they needed and the people outside just became weak. Then they went out and decimated them. So the city-state was a very powerful kind of invention.

However, at the time of the Phoenicians developing those great big ships we then have the beginning of Crete. Crete didn't have any walls. It didn't need any walls because it's ships were so powerful that they were overwhelming other ships. The line of supply, then, began to be carried by the ship. You could carry much more on the ship than you could on the backs of animals or human beings. We have then the fall of Troy. Troy was really a city-state guarding the traffic coming in from Asia going into Europe plus picking up a lot of small boat traffic at the head of the Aegean. And we had Troy falling because finally the Mycenaens and the Cretons developed an alliance and they controlled all the sea traffic going in and out of the Aegean and into the Mediterranean and to the west. So we have suddenly the Mycenaens going to Troy with the great wooden horse. They had a ship that would carry horses and plenty of them, and ships that could keep going back and getting the food. So at this point, the control of human affairs on our planet was by those who controlled the line of supply.

The line of supply gradually became more and more important. The Roman Empire carried their line by building overland highways, great paved highways, as they did all the way from Italy to England. But they were being out-performed. The traffic you could carry on ships was so much greater. Gradually they didn't keep up their navies enough so out they went.

Now, I want to have this understanding then. There's Magellan discovering that we're on a spherical earth. And you've learned that by far the greatest wealth-making could be done in ships. We have Queen Elizabeth and some of her friends setting up the East India Company and having their headquarters in Madras in India, way away from England. Then there was a 200-year battle of those who were very powerful and ambitious human beings--always operating behind the name of some nation to use the military power of that nation, but not being really that nation itself--operating, then, through Portugal and Spain and France and so forth, all trying to see who is going to control the great lines of supply between the Orient and Europe. Because just that one ship coming in would give you vast fortune. So, we have 200 years of such battling and then comes the Battle of Trafalgar. With the Battle of Trafalgar, *Britain* becomes <u>the</u> first great world empire. The first empire in which, they said, the sun never set. In other words, it was the first empire that was a spherical empire. This was not taught you in college, but the point is that's what it was, in counter-distinction to flat empires.

In the meantime, in those 200 years before Trafalgar, the British sovereign had all kinds of explorers going out and taking scientists, like Darwin, around the world to find out what all the resources of the earth were that they could exploit, and they began to get control of the high seas lanes. They had then these explorers recording enormous amounts of data about all the economic exploitability of the planet and all the customs around the world. Having won the Battle of Trafalgar, they then created the East India Company College in England, just north and east of London, which received all the data that had been collected for 200 years.

Then we have on campus a professor of political economics, Thomas Malthus. Thomas Malthus was the first human being in the history of humanity who had the total vital statistics around a closed-system spherical earth. He realized the difference between that and an open-to-infinity planet empire. And he said, quite clearly the data shows that humanity is multiplying, increasing its rate of self-multiplication at a geometrical rate and increasing the rate of its life support only arithmetically. Quite clearly, the majority of humans are going to have to go through life in great want and pain. He said, pray all you want, it won't do any good. That's all there is. Now, this is a very hard dictum, but it seemed to be absolutely scientific because it was a closed system. You can be scientific because you have a closed system.

Incidentally, at that time the literacy of humanity was so general very few people knew what Malthus had found out, what he was saying. What he was saying was really highly classified and was really only of interest to those who were highly ambitious to try to take over the control of the lines of supply.

Fifty years later we have Darwin promulgating his theory of evolution, and explaining this theory of evolution as consequence of survival only of the fittest species and only of individuals within the species. We have then his contemporary, Karl Marx, in England saying, I accept Malthus as absolute science; I accept Darwin as pure science. Quite clearly, where there is nowhere nearly enough to go around, the worker is the fittest to survive because he knows how to handle the tools to produce the goods. He knows how to nurture the seed and the lamb. These other people are parasites. The other people said, obviously we're not parasites. According to Darwin's survival of the fittest, we're on top of the heap. We're on top of the heap because the workers are so dull, they have no imagination, no enterprise and so forth that is needed. This brought about the two great political camps throughout the planet since that time. We have each one saying, and still saying, you personally may not like our system, but we're convinced we have the most practical, most ingenious way of coping with the lessening adequacy of the life support on our planet. But because there were others who disagree diametrically on how to cope, we can only determine by trial of arms which is fittest to survive. That is why Russia and the United States for the last 31 years have been appropriating over $200 billion a year, last year $400 billion--amounting to a sum total of $600 trillion--to buy the highest scientific capability to kill more and more people at greater and greater distances in shorter and shorter time. Just think of it.

So I go back to what hit me and hit me very hard in World War I. It had to do with what I spoke to you about earlier, what are called "invisible realities." Because we're going into invisible realities, society can't see it, so they don't really realize it and they don't talk about it that way. In the navy of World War I, in counter-distinction to all the navy engagements up to that time, which you see in all the paintings on old walls of these great naval ships, they say how many tons she is: 350 tons, 700 tons, 100 tons. In World War I the enemy had exactly the same number of classes of ships that you had different types of fighting. He had the same tonnage that your ship had, the same number of guns, same calibre. You're coming together, as far as he knows, 50-50. But what he doesn't know is that you suddenly get in a

new alloy of steel. Your new alloy of steel is so much stronger, your guns can fire accurately 10,000 yards further than his can. So when he gets within your range of 10,000 yards, before you're within his range, you fire. He goes to the bottom and he never knows what happened. Because this is all invisible, it was very easy to keep it secret. That was the secret weapon of World War I: alloys. They were doing more with the same and more with less.

Now, I was terribly concerned by the fact that we were using all of our science and technology just for destruction. It hit me very hard that, in view of all the things that I've said, what did Malthus not know about? He wrote his last book just about one year before the telegraph was invented, for instance. He assumed that if a message goes from here to there, it'd go by horses and all. He didn't know that we were going to take tin from the Malay straits and iron from Masabi and manganese from southern Russia and put them together and make a tin can and have food that used to rot reach people all around here. I began to make a list of all the things that Malthus didn't know about that we've been doing technologically since that time. He assumed that if you wanted to get a message across the sea you had to send a great ship. He didn't know that I in World War I had my radio, a few pounds of material. It looks to me as though we might some day do so much with so little we might really render Malthus non-correct. In other words, this may not be a scientific generalization at all but a very special case, a longlasting special case.

So I committed myself. I could see that in 1917. I came out of the navy and went into the building world. I did get up 240 buildings, small building, residences, real small commercial buildings, and I found the building world thousands of years behind the arts of designing and environment control for the sea and particularly this new environment control for the sky, where you didn't float, you had to actually pull yourself into the sky. So you had to do a whole lot with very little.

Imagine a little airplane with its aluminum skin that takes off from an airport where it's 70 degrees above zero Fahrenheit and in a couple of minutes it's 45 degrees below zero, and this little thin wall makes you absolutely comfortable. I said, I can see then that if I use the most advanced science and technology I may be able to really alter things very rapidly, particularly in the field of the home where this kind of science is not getting in.

This building we've been having trouble about tonight, for instance. Does anybody in this room know what this building weighs? Can anybody tell me within a thousand tons, ten thousand tons, a hundred thousand tons? Does anybody know what any building weighs? Do any of you know what those big oil tankers weigh? Getting up to 500 thousand tons. Remember what the old Queen Mary weighed? She was 85 thousand tons. A Boeing 747 fully loaded--350 tons. You know exactly what your modern technology can do per pound, what its rate of climb is, everything about it, but if you don't even know what your buildings weigh, you're obviously not doing that kind of thinking. Apparently, the building arts are thousands of years behind the arts of designing environment controls for the sea and the sky. They seem to stand still. They're just a translation of the old focus from the city-state, the bigger and heavier and higher the walls, the more secure.

For instance, the plumbing. No scientists have been asked just to look at the plumbing. If you go to the old palace of Knossos of Crete you'll find the present kind of plumbing. The only difference is they've put in a water seal so that the sewer gases don't come back. That's the only improvement--I'm going back 4,000 years! Scientists look at the plumbing, but then they call for the plumber. Here we are, all of us, with nature taking all the trouble to evaporate the water, get it into the sky, so it comes down beautiful pure water and every one of us several times a day uses three and four gallons to get rid of a pint of yellow. Anybody doing anything about conserving the human wastes which could turn into extraordinary methane gas and beautiful fertilizer? No science has entered into building at all! I saw then way back that if I really began to commit myself to living from inside, doing more with less, we really might get somewhere.

Now I would like to come over to structure for a minute because I find structural engineering and physics really extraordinarily ignorant in these matters. I would like to speak to you a little bit about all structuring which consists of two main forces. The coming apart force is what is called "compression." All radiation is compressive, explosive. All the gravity is "tensive." We have tension and compression always and only coexistant in every structural member. Let's take a rubber tube, four inches in diameter, seal it up with disc ends of steel, and fill it with water. If I pull on it like this, the harder I pull the more it contracts in the center here. In other words, as I pull it this way it goes into compression at 90 degrees. Can you see that? If I push on the ends, it will bulge in the center. If I'm pushing this way the center goes into tension and the circle gets bigger and bigger. Tension and compression always and only coexist precessionally at 90 degrees to one another, the way I spoke about the ecology operating. So now, enough with that.

Compression columns loaded want to bend. Tension wants to thin out. It's a very different matter. This gets to a critical enough bending, then it's going to break. It gets to a critical point. We have then Greek columns' slenderness ratio, 80 diameters high, as high as they go before they're going to automatically tip over. Steel columns today, we get up to 40 diameters high before they go banana. But there's no cross section limit in dealing with tension. See then that when we get into tension we get better and better alloys.

I want you to think about that mass and attraction law of Newton's, where they're not touching each other. We have two stars like this. Put a third star the same size in the middle between the two and you increase the attraction four-fold. So, if you half the distance, you increase it to the second power. I can see then if we make an alloy where we don't have any atom touching the other but we have another atom in between the two we could get greater and greater tensile strength without anything touching anything there.

I see, then, human beings born on a planet, absolutely ignorant, learning by trial and error, without even knowing the word "gravity." They finally put a stone on top of a stone and it stays there, but a stone beside a stone doesn't stay there. In other words, they can't grow horizontally but they can grow vertically, because gravity is holding it together. But there was a limit to

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the height you could go. The next thing I saw then was that the masonry of history has 50 thousand pounds of compression resisting capability. 50 thousand. But masonry tension is only 50 pounds. It's a thousand times more effective resisting being pushed together, crunched that way, than it is being pulled apart. So when we want to go horizontally--I want you to think of two walls and a beam. I load the beam on top here and it appropriately acts like a fulcrum and wants to pull apart. So we have tension in the bottom. We could get wood up to 10 thousand pounds per square inch tensile whereas the masonry only went to 50. Then we did our horizontals with wood but the wood rotted out and burned out long ago. In the great antiquities we only still see the brick ones standing, because gravity is holding them together.

We gradually then learn to get metal out of the stone. By 1851 we have our first production steel. First production steel comes into 50 thousand pounds per square inch tensile strength and compressive strength. In other words, it has the same compression strength as the masonry but it has a tension equal to that. Then we get to the Brooklyn Bridge, 1883, got some carbon atoms in the right places, and we went up to 70 thousand tensile. In World War I we've got what we called aircraft chrome aluminum steel and we got up to 110 thousand, now double the mild steel of 1851. And weighing exactly the same. Suddenly, all this weighing the same and doing twice as much. Invisible. People don't see it. World War II, we got into chrome nickel steel, 350 thousand tensile. Since that time we've got into the laboratory and there are three different materials that have gone up to one million pounds per square inch. But practically speaking, we've gone up to 600 thousand pounds tensile strength. When the little Gossamer Albatross flew across the English Channel by foot-pedalling by a man, they didn't tell you in the newspapers that the materials did ten times as much as the same weight of any material before. These common fibers, this is what they put in the sails of the Freedom, in sailing the six meter America's Cup Race here and so forth, which go under an enormous head of tension and weigh the same. I find these the kinds of things that society didn't see, at any rate.

We then get into reinforced concrete. We didn't get into sealed frames and skyscrapers until after--we didn't get into reinforced concrete in an important way until this century but primarily not until after World War I. Then we began to add a little more tension into the pattern. In all our structural engineering today, the prime analysis of the strength of the building is predicated entirely upon the compressional continuities--assuming compression touches compression. I saw this was not the way nature operates. When you try to load a car and want to get the most possible, you load it as close as possible to its neutral axis so it won't want to banana one way or another.

Let's take that rubber water-filled column I gave to you before. When we load it at the top, it gets to be a cigar and then it gets to be a sphere. In the spherical condition for the first and only time any aspect is neutral axis. Spheres, then, became the best compression method humanity ever made, so we made steel ball bearings. I saw that nature used that entirely. Nature doesn't have compression touching compression, the way man has to have brick against brick against brick. Engineering says that brick has to touch the brick. Nature had islands of spherical compression and continuous tension, but no continuous compression whatsoever. There's your moon, there's your

earth, there's an atom. We're dealing then with these spherical islands of compression.

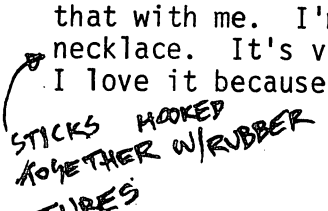
Can man do that kind of structuring? When he developed the wire wheel he did. He then had an atoll of compression in the rim and an island of compression in the hub, and it took all its controlled shape out of the triangulating of these tension spokes. It had, incidentally, a minimum of twelve spokes, six positive, six negative. In order to have any structural stability, it always has to have six positives, six negatives. This is where structure begins, the number six is in there--six positives, six negatives. Now, I said, can you make them spherically? With the wire wheel we got to doing exactly that. I can remember back in the early Fifties we did a twenty-footer of this down at Eugene with the University of Oregon. I had thirty struts here. These were just little wooden struts. They're held together only by dacron coated line, the stuff you clean your teeth with. No compression ever touched another compression; in other words, bricks don't touch bricks. There is just a continuous tension network. There is no open-end tension. All the tension comes back to itself. All of them are trying to do exactly the same. If I tighten just one of them anywhere, they all tighten just absolutely evenly. They distribute their load completely at all times. See. Bouncing, distributing its loads. [TOSSES SPRWLY STRUCTURE ON FLOOR]

Now I said this is the way nature is doing her structuring, and when you get into this, tension has no limit. Let's go back then to what was cleverly discovered, operating just between the sun and the earth, 93 million miles and no cross section at all, holding together. This is the way nature is doing things: discontinuous compression, continuous tension. Once I get it, there is absolutely no limit, it clear spans.

The way I understand geodesic structures, incidentally, is each one of these struts represents a cord at a central angle for the center of the sphere. That's a very wide angle in here. We find then that if there is a difference between the center of the cord and the arc, the arc altitude, as I increase my frequency (making more and more members instead of having them long and awkward) which I can do, as there is an increase in frequency, the arc altitude decreases. We get then finally to where, as in most geodesic domes, the members touch each other but they're not fastened one way or another. They just come with the touching, taking the spiggyness out of the system so that they become very stable. But geodesic domes have absolutely no limit to clear span. Absolutely none.

This is a very different story. Some of the largest clear span domes in history when I developed the geodesic were the Saint Peters in Rome and the Pantheon, both 150 feet clear span. Since then we began to go out. We can go any limit, there is no limit any more. This is very, very important for all of you.

The next thing I want to come back to is I said I feel we're still very much in the Dark Ages, and I'm going to give you some ways of kind of feeling that with me. I'm going to be a little child and I have found my mother's necklace. It's very fascinating because it takes on all these different shapes. I love it because it takes all these different shapes. But I begin to look at



it so many times that I begin to realize that the sticks are not bending, the sticks are not getting longer and shorter. So whatever is making it take its shape is in the tension joints between them, not the compression struts. Instinctively as a child I take out some of the struts. I get rid of a couple of them and put it together again. It still is a necklace, works, I can still get my head through it. But then I take out another one. Put this together again. It still is a necklace. Let's take out a couple of more. Put it together again. Still is a necklace. Three down my front, three down my back. Remember when the teacher went to the blackboard and said, that is a square? The only reason it was a square is because the blackboard held it there. This is terribly important. So as a little child I'm going to take one more out. And I realize that if I take two out there won't be any hole in it. I can take only one more out now and still have a hole in it. I put it together again. It doesn't--- IT HOLDS ITS SHAPE! The terminal case is holding its shape!

Then I found that physics and engineering had no definition of what they meant by structure. They had a self-evident block or blob that holds its shape, a thing called solid, rigid. They said this was self-evident, not realizing what nature was really doing with atoms there. I say this consists of six different parts: three push-pull compressions, and three tensions, and yet it's holding its shape. I mean by "structure" a complex of events that interact to produce a stable pattern. It's a complex of events that interact to produce a stable pattern. I said, why does it do it? Well, we learned about the lever long ago, didn't we? As a child you learned to use a screwdriver in opening a can. You learned that if you take two levers and put them together you get a pair of shears, and the longer the handles of the levers, the more powerful the shears. Right? I see that what goes on here is this side here is a push-pull, and I'm taking hold of two levers. It was Galileo who showed you could have a flexible fulcrum which worked equally well to a compression fulcrum. So here's two levers and this third side takes hold of the ends of the two levers and with minimum effort stabilizes the opposite angle. It was the angles that were changing the shape.

So here then is nature's way of getting a stable pattern with minimum effort. That's what nature's always doing. When I say triangle, I mean triangle as structure, structure as triangle. No other polygon has any structural integrity whatsoever. As a terminal case, you can feel very, very comfortable about it.

The next thing--a teacher told me a point was sub-dimensional. Then she took a number of these sub-dimensional points and made a line which she said was one-dimensional. I couldn't understand how she got one dimension out of *non*-dimensions, but she did. Then she made a raft of those one-dimensional lines and called it a plane, said it's two-dimensional. And to her it was absolute reality. So then she piled them up and got a cube and said, there's what we call reality, three-dimensional reality. I said, how old is it? What's it weigh? What's its temperature? It didn't have any of the characteristics of reality whatsoever. At any rate, that's what they taught me about in school, that that cube was reality. And I want you to think about it.

What I heard, then, was saying that a point didn't exist. The word "point" comes out of an experience. You point because it's something you can

see there. Really what you see is light bouncing off something and coming back to you optically, isn't it? It's bouncing off the surface of something. You can't have a surface of nothing. Anybody who can give me an experiment for the surface of nothing? There are very many mathematicians who get a pretty good salary for playing games with surfaces of nothing, but it's of no interest to me whatsoever. Now, I really wanted to know how nature was doing things, not play games with surfaces of nothing.

One of the most important jokes played on us by the Dark Ages was that perpendicular, parallel, flat earth. The universe is not operating that way. We're convergent and divergent. We grow or we shrink. The radiation goes out that way; it's convergent-divergent, not perpendicular-parallel. So in order to have convergence-divergence I'm interested in phenomena which is the surface of something. What is the minimum something? What is the minimum that can have a surface? I found that two loci have "betweenness." Three loci have "betweenness." But four loci have "insideness" and "outsideness." It takes a minimum of four loci to have insideness and outsideness. This is what I call a "system." A system divides all the universe. All the universe is outside the system, all the universe is inside the system. A little bit of the universe that is the system does the dividing. This is the very essence of our thinking. When you say I'm thinking, anything you're talking about is microcosmically irrelevant. It's way outside the system. It's not inside the system. In this way the very essence of thought is systemic.

All right, then, this is the minimum system in the universe. If you take a rock and keep breaking it up you can't get less than four corners. You can't get less than three faces around a corner. You can't get a face with less than three edges. This is the minimum system in the universe. And not only does it have four corners, four windows, but it has six edges. These six edges are the energy vectors, energy vents, and they are giving it a shape. So this being triangular is the minimum structural system in the universe. With the tetrahedron, which they don't even teach at school, I can also get four equal-area triangles or equal-angle triangles around each corner. You divide the universe inside and outside, therefore it's a system. It's all triangular, so it's a structural system. I call that the octahedron. I can get five equilateral triangles out of each corner. You can't get six, because they'd add up to 360 degrees and it would be a plane going to infinity; it would not come back to itself to do the universe either inside or outside. The only three structural systems in the universe are the tetrahedron, the octahedron, the icosahedron. It would be very easy to teach that in kindergarten, but it doesn't happen to agree with the Dark Ages business.

Once you go out of this place you're going to realize how still completely immersed you are in the Dark Ages. I have this watchchain. I love this watchchain, and I'm sure many of you know enough about crystalography to know that you find natural shaped crystals, the way the atoms shape themselves. The tetrahedron: you just take two spheres of equal radius touching each other. Can't get any closer; looks like a dumbbell. The third can nest in between the two making a triangle. The fourth can nest on top. There's your tetrahedron, the simplest structural system in the universe. The first two can roll around each other very freely. They can't get any closer but they can roll around each other. When the third comes in and touches them, it stops them

doing that, but they can then hinge with an axis on one of the sides so they can involute at the top and evolute at the bottom. But when the fourth comes in there, they can't move anymore. For the first time they're actually immobilized. This is then a tetrahedron.

Now, on my watchchain here I've got these beautiful crystals picked up off the ground that are fluorite crystals, beautiful tetrahedrons. This is a lovely fluorite octahedron. This garnet is the rhombic dodecahedron, twelve diamond faces. This next one here has twelve pentangle faces. These are the natural crystals. They are entirely this set here. Nature doesn't have any cubes. It may look like a cube once in a while; it was truncated, one of the corners was gone. The reason that we have anything that looks like a cube is because if we take that cube it has six faces, and in order to make this a total shape as we do in our building you put little triangles in the corner. You've got to triangulate. Then you have this long lever against the triangle, but the best way would be to make a diagonal with the whole face. So I make a diagonal with each one of those six faces. Those are the six edges of the tetrahedron. Whenever we find something that looks like a cubical shape, it is simply because the tetrahedron is holding it there.

It is very, very important for all of you to feel these things structurally. The next thing I'd like to point to is my own seeking for how to develop the most environment controlling for humanity under the greatest stresses possible. The tetrahedron then had six edges. The six edges gave it the shape. I'm going to call those six, because there always have to be those six--but each one is push-pull so there are actually twelve--there are twelve fundamental degrees of structure in one universe. If you don't take care of them, there is no structural stability. Structural stability depends on those six, six positive, six negative.

When the tetrahedron's volume is one, the octahedron has a volume of four and it has twelve edges. Twelve is two times six, so it has then two sets of structural quanta. This is one structural quanta. On the icosahedron I have 30 edges, divided by six is five. I get here one volume for one quantum. Here, I get two volumes for each quantum. And here, I get approximately four volumes for each quantum. I get the most volume with the least structural investment in the icosahedron.

Now the next thing is when humanity and biology tend to get interested in biological design control done in genetics. In genetics, we get into chromosomes. With some mathematical probability statistically about control of design we began to use the fruitfly, which regenerated very rapidly, to see if we could find any controls going on. Then we found that tobacco mosaic virus regenerated very much more rapidly, and that got us into virology. In the world of virology, we came suddenly to discovering DNA, RNA. And within the world of virology, DNA, RNA, the inside of the protein shell is a virus.

I began to get letters from a Dr. Klugg, University of London, some twenty years ago, where he said he was making x-ray defraction studies of the protein shells of the viruses containing the DNA, RNA. And he said he'd been looking at my geodesic domes which had been published very widely, and he seemed to find some resemblance between the numbers of nodes of my geodesic

domes. I said, yes, I can tell you the number of these nodes will always be frequency to the second power---frequency means modular subdivision, so it would be additional nodes in here---frequency to the second power times ten plus two. The last year the Herald Tribune was published in New York the world virologists had a meeting on Long Island at Cold Spring Harbor, and they published on the front page the fact that my formula, frequency to the second power times ten plus two, had proved to be the number of the nodes of the protein shells of the viruses. Which simply told me that nature had gone through the same argument I'd gone through here: how do you get the most structure with the least weight and the least material? That's what I was looking for, whether we really could get humanity environment controlling to really do so much with so little.

This, then, is the very essence of my message to you tonight. Because I started then back in 1917 interested in increasing these tensile strengths of the invisible world, I got into---

EDUCATION

There's one other question I'd like to introduce. I try to keep track of all these these great curves of doing more with the same and more with less. At any rate, I'd like to compound what I've said to you tonight about the fact that we're dealing in an invisible reality by going into something called "power structures." We'll find that every little child is born interested in everything, asking you most beautiful questions about microcosms because human minds define relationships, and their little minds go right to work. We say to the child, wait now till you go to school. They'll tell you about that. When you get to school, they say, never mind about the universe, darling, I'm going to give you an "a," "b," and "c," and if you can handle that I'll give you a "d," "e," and "f." With elementary education, we've just fragmented them completely.

Then, we get to something I call "power structure." We find a herd of wild horses. There's a king stallion. Every once in a while there's a young stallion who's born in the herd, much bigger than the others, and when he gets to full stature the king stallion battles him. Whichever one wins is the one who's going to inseminate the herd. That is the way Darwin saw nature conserving the strongest strains.

I can see then going back to early, early human beings that once in a while a big man was born. He didn't have to be, but he was bigger than the others. And a little man says, hey mister, can you reach the bunch of bananas for me, I can't reach the bananas. So he reaches bananas for people like that. And they say, mister, the people on the other side of the hill have lost all their bananas, they're dying of starvation, and they're coming over to kill us. You get out in front and protect us, you're big. So he gets out and protects them successfully. This goes on and on, and he see himself being continually exploited for his bigness. So he says to these people, between these battles, I'd like you to get me some walls and some weapons, for I would like to be your king. So you understand he got to be king very easily. Then along comes another big man from another tribe, and he says, this king has things too easy around here. I'm going to take it away from him. So they have a big physical battle and the king wins. The king has him down on the ground and he says, you were going to kill me to get my kingdom weren't you? Just one more second

and I can kill you, do you understand, feel it? I need fighters around here and you're a pretty good fighter. If you promise to always fight for me, I'll let you up. How about it? So he lets the man up and the man agrees to always fight for him and so forth. Another big man comes along and the king licks him, but now here's what you call the power structure. He's on top of the heap physically. He says, instinctively, don't let two big men come at me at once. I can handle them one by one. The prime instinct in the power structure is to divide to conquer; to keep conquered, keep divided. So he makes this big man duke of hill A, this one duke of hill B, and he has his spys watch so that they don't gang up on him.

So his kingdom is getting on a little better on account of all this fighting capability, but there are a lot of little people who annoy the king very badly. They won't obey him. So he has the big men bring in this one little character and says, look little man, I'm going to cut your head off. You're a nuisance around here. And the little man says, mister king you're making a great mistake. The king says, you're impertinent, too, eh? Well, why shouldn't I cut your head off? Well, I'll tell you, mister king, I understand the language of your enemy over the hill and you don't. I heard him say what he's going to do to you and when he's going to do it. Well, young man, you've got a pretty good idea there. You let me know what my enemy over the hill says he's going to do to me regularly and your head's going to stay on. And then you're going to do something you never did ever before--you're going to eat, regularly, right here in the castle with me. I'm going to put purple and gold on you so I can keep track of you.

Another man is making trouble and the king says, I'm going to cut your head off. But it turns out he knows metallurgy and knows how to make better swords than anybody, so the king says, I'm going to make you the royal armorist. Stay right here in the castle. Someone else says, mister king, the reason I can steal from you is because you don't understand arithmetic. All right, I'm going to make you the court mathematician. Now he has all this beautiful logistics information, he has the fighters in his kingdom getting very large and successful, and he decides he'd like to turn it over to his grandson. He says, I can see you're getting pretty old. I want you to teach somebody about that language, about that metallurgy, about that mathematics. This was the founding of Oxford University.

SPECIALIZATION (DIVIDED)

So the power structure: divide to conquer, to keep conquered, keep divided; and keep all the bright ones specialists. That's where all your specialization came from. You're all inherently comprehensivists. That is what you mind is for, and every time you get specialists to feeding the mind you're making it very difficult to find any generalized principles. So I want you to realize we're still very much a victim of the Dark Ages, of the great old power structures, the fact that everybody is specialized, and we're dealing with an invisible revolution. People don't realize that those things are going on. They may know what is going on in their particular field, but I can tell you not only do we have that Gossamer Albatross doing what it is doing, but, say, fifty years ago we had a new transoceanic communications satellite, weighing three-quarters of a ton, out-performing the transoceanic communications capability of 375 thousand tons of copper cable. I can tell you ten thousand kinds of these ways of doing it. We may not really see them all because they're

invisible, but luckily I kept track of all these curves. Furthermore, I began to always put them to tests to find out if I could actually reduce them to practice and develop environment controlling structures. So there are now over 200 thousand geodesic domes around the world. My knowledge of logistics is very, very, very great. And I have kept track of these curves.

Ten years ago I came to the point where I could say absolutely clearly, clearly demonstrate to any engineers who wanted to study what I had, it was completely feasible within a ten-year design revolution, where we would take the metals going into the armaments and so forth and melt them, that we could take care of all humanity at a higher standard of living than we'd ever known and do it within ten years. And we could do it on a completely sustainable basis. We could go on completely without any use of fossil fuels or atomic energy--we could live entirely on our energy income. This is absolutely clearly demonstrable, engineering-wise.

Incidentally, for the engineering side of it, you can read a book called Energy, Earth, and Everyone, published by Doubleday, by Medard Gabel, who runs my world game. He also wrote another book called Ho-Ping Food for Everyone that makes it absolutely clear that there is adequate food today to take care of everybody. There is no excuse for anybody starving.

Now then coming back to all the conditioned reflexes, all the specialization, society then, dealing in invisible reality and not realizing we have this potential. I was shocked to discover when I was able to make such a statement as that, to find myself checked out by at least a thousand very capable people who know that I'm correct, and then to find that all the big government and all big religion and most of big business would find it absolutely devastating to their activity to have humanity a success. They're all organized on the basis of humanity as an inherent failure. Come around, I'll give you a turkey dinner and get you into heaven. Come down to city hall, kid, and I'll give you a job. All work on the basis of the great suffering of humanity, by playing that game. Come to find out that none of the big organizations are in any way in favor of trying to realize what I'm talking about. I now know it doesn't have to be you or me. I now know you don't ever, ever again have to rationalize why it is valid for you to deprive this guy so your family can survive when the others can't. We had to do some very horrid things on the misinformation that there's not enough to go around.

Anyway, I now know that war is obsolete, the service is obsolete, etc., etc. So I now said, what is nature doing here? Because we are humanity, united designed humanity, and we are here apparently with this extraordinary capability of the human mind. So--I'll be through really very quickly--

You can tell what I'm talking about is the very great crisis of humans on our planet. We're at the point where we do have that written word, we do have that communications capability and these facts are now available to us. Never before in history could you do it. It was only because of learning how atoms could go together one way or another that we can do it. That's all I wanted to get at in a sensible way. So this is not something we could have done long, long ago. This is a new set of conditions, it's a new challenge, its invisible, and completely unknown to the four billion human beings on our planet.

So. Then, the next thing. I see then that nature does some very extraordinary things evolutionarily. Historically, male and female--the female, carrying the young, could not cover as much geography as the male. The male, covering more geography, did the hunting. She stayed around the house and kept the fire going and consolidated the gains, but daddy because in hunting he could get to the top of the mountain, could tell you what he could see from the top of the mountain. He could also tell you what the king of the next tribe said. Daddy and mom were the authorities throughout history of what was safe for you to eat, and what you could get away with in the system you lived in. Daddy and mom were the authority, and they were imbued with some sense of extraordinary protection of their young. We have daddy, in addition, as the "newsman." And daddy's language was atrocious. This is the way he said it and the kids then automatically copied that because he is the authority. So this brought about esoteric dialect after dialect and more and more language differentiations. Suddenly, in comes that invisible world, the electron. (Incidentally, when I was getting ready for Harvard, in the back of the physics book a yellow section had been pasted in called "electricity." That's this thing that's coming in now.) Suddenly, that electron is there. When I'm twenty-three years of age we suddenly had the human voice on the radio. When I'm 27 we had the first licensed broadcast station. Suddenly, in 1927, the year I was 32, all the daddys are coming home one evening in May and all the kids say, daddy, come listen to the radio. A man is flying across the Atlantic! Daddy says, WHAT? And daddy never brought home the news ever again.

Nobody thought of this anthropologically, but it was an extraordinary anthropological moment, because the people who got the jobs on the radio got them by virtue of the commonality of their diction, not the esoteric way that daddy said it. They got it by virtue of the size of their vocabulary and their versatility in using it. The ability, then, to communicate to the many. Before, the kids assumed that dad and mom were the authority all right. When they saw mom and dad go and tell the people next door what the man had said on the radio, quite clearly to the parents the man on the radio was more of an authority than they were. This is a greater authority, and this is the way a greater authority says it, so everybody emulated that language. This completely changed the language pattern of humanity; it did not come out of school, except the kids who got the jobs on the radio had gone to school and somebody had developed this more common language. Anyway, this was an evolutionary event of the highest order.

[Pause in tape]

. . .speed of sound, 700 miles an hour. Sound only operates in air and on gases, on atmosphere. Speed of light, 700 million miles an hour. The light goes right on through the universe. The information you can get from your eyes is a million times what you can get from your ears.

In 1965 we have the beginning of the great news of the world, that the students at the University of California became the first dissidents to say the educational system wasn't completely satisfactory with them. That particular group asked me to come and meet with them in Berkeley and I did. I met with many of their contemporaries that year at different colleges, all asking me to come. I found they were born the year the television came to the American

home, and every one of those kids was saying, I know dad and mom love me to pieces. I love them to pieces, but they don't know what's going on. They come home from the shop and say, let's have a beer and turn on the television. They don't have anything to do with going to Korea or Vietnam. They don't have anything to do with our going to the moon--dad and mom don't have anything to do with anything. And quite clearly, these kids had found that people all around the world were in trouble, and their compassion was for everyone around the world. You could never again get them into a little, local, community way of looking at things anymore.

We suddenly had then, quite in counter-distinction to when I was young (my father died when I was very young), my mother said, darling, never mind what you think, we're trying to teach you. It was the working assumption of that older world that the cerebral processes of the young were absolutely unreliable. They were sort of un-jello'd jello. And nature suddenly cut that off completely. Instead of the older people being the authority, the kids suddenly said, dad and mom don't know what's going on. I've got to do my own thinking. The world is in trouble. This is a very new kind of experience. We said, that hair is trying to come out, I'd better let that hair come out. This was a decision of extraordinary integrity beginning to manifest itself in these young people making their own decisions. They didn't know exactly what they ought to be thinking about, but that's the kind of thing that would hit them. Russia and the United States spending $200 billion a year, about $20 billion a year on what are called "psycho-guerilla warfare," how to break down the other man's economy before you get to it.

These kids were immediately idealistic, doing their own thinking, and were completely exploited at the outset. The kids then said, I'm using my head as a battering ram. I'm supposed to be using it for thinking, not using it as a battering ram, so they began to develop an immunity. And today, I find all around the world that the young have developed almost complete immunity against being exploited by the political systems which they have functionally no faith in whatsoever.

What nature was doing very powerfully when I was young--humanity was completely deployed remote from one another. Using the fastest transportation available when I was young, the remotest places were six months apart. My father had a leather business in India and Buenos Aires and Boston. It took him two months to get to Buenos Aires, two months to return. It took him three months to get to Calcutta. This is the way life was, and when Kipling said, east is east and west is west and never the twain shall meet, everybody said that's absolutely logical. We had no idea we were going to have airplanes. I was eight years of age when the Wright brothers first flew. These things are very, very recent, these things that seem everyday to you, but they've only just happened.

Now, then, we have humanity which used to be completely remotely deployed. the year before I entered Harvard, the president of Harvard retired, President Elliot. And he and his wife and granddaughter did something that had never been heard of before, they undertook to make a trip around the world, wherever they could buy their way on a steamship or railroad of some kind. The newspapers followed them around the world--nobody had ever tried to do such a

thing. Just think of all of the people who go around the world today. I'm one of over ten million in my class who've gone around the world 47 times. It's one of the most common things to do.

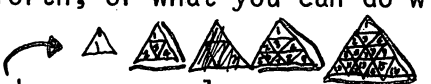
So we have all of humanity, where yesterday we were deliberately deployed remotely from one another, learning special things and being completely integrated just like that. When I was young, we walked from here to there. Only very rich people had horses, and we walked. We were really very interested in how far you walked. We found the average human being, the postman, the butcher and all, walked eleven thousand miles a year. As we entered World War I in America, we were walking eleven thousand miles, but we were riding four hundred miles. World War I was enormous mobilization, getting wheels going with enormous power added over and above the muscles of humans and animals. By 1919, we were riding eleven thousand miles as well as walking eleven thousand miles. We were still walking eleven thousand, but as we came into World War II the average housewife was making ten thousand (riding) in addition to her walking eleven thousand.

This means we used to stay within the local area. On the plains, the horizon was fourteen miles away. To walk to the horizon and back on the plains is 28 miles. That's much more than a good day's hike, so very few people ever went to the horizon. People stayed put up until yesterday. The average American family moves out of town every three years. We've completely redone things going on, from everybody operating all by themselves, not knowing what the other case histories are, not realizing that nature's very swiftly undertaking to integrate all humanity. And what we call a nation, groups of individuals who were isolated for thousands of years geographically, were those who did survive under those particular geographic conditions, co-habitating and producing (like you inbreed horses) and concentrating special genes, these special characteristics. Russia had 148 nations to integrate. They looked absolutely different from one another. This is when we do this long inbreeding of local geography. America is a crossbreeding of human beings.

We're at the beginning of a whole new phase. For instance, the great Club of Rome, the limits to growth, looked at all the mines around the world and found that the mines are being exhausted, not knowing that metals just don't get lost. 88% of all the copper that's been mined in all history, we know just where it is. 80% of all copper comes from scrap today, not from the mines. 70% of all the steel comes from scrap. We're at the point where every time they come around, we're doing more with less in these invisible ways. They average, the things coming out of the home, 50 years before they get out of a house, the copper pipe and so forth. The average of all these metals comes out every twenty-two years. Every twenty-two years they come around again, and every time we've learned how to do so much more with so much less for so many more people. This becomes the lifeblood of our taking care of more and more people. We find then that all these nations want to block that. They develop their own mines. Don't come into my country, and so forth. Say we have 150 animals in one ship, and all those animals have to go. We're going to have to come to one world, where we have one Spaceship Earth. And probably within ten years, if not less, all the nations are going to have to go. They are 150 bloodclots here. 150 bloodclots. All organized on the basis of being isolated and protecting themselves, being isolated, when exactly the opposite is going on--integration.

Okay. I say then very fundamentally to each one of you: having this extraordinary function of the human mind which no other phenomena we know has, access to the great design of the universe, it is my assumption that we are here for local information gathering, local problem-solving. When I was 28, another galaxy was discovered. Since that time, since I was 28, we've discovered 2 billion more galaxies. The rate of information gain is like that. Because we've learned that every chemical has its own unique electromagnetic wave frequencies, we now have a reach of eleven and one-half billion light years with our optical telescopes. And we've been able to take all the light from two billion galaxies of over 100 billion stars each and run it through a spectroscope. Human beings on our planet, small as we are, have a running inventory of all the relative abundances of all the chemicals present, the relative abundance of it. The exactly relative amounts. Within eleven and one-half billion light years around us--that's how big our minds can be.

If any one of you kids say, what am I going to do about it, I'm going to give you--the blackboard, I had a blackboard a minute ago--- I was going to say that what is going to happen is only a matter of your personal integrity. When you get experimental evidence as I have been giving you here, are you going to go along with the tetrahedron as the structural system? Are you going along with all these tropological characteristics of the numbers of the vertices and so forth, or what you can do with the really beautiful mathematics of this?



One to the second power equals one. You've got two. Two to the second power equals four. One, two, three, four. Three times three, three to the second power equals nine. One, two, three, four, five, six, seven, eight, nine. Four to the second power equals sixteen. One, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen.

You say trianguling instead of squaring. Every square is two triangles. Nature is always most economical. When nature multiplies itself times itself, which it is doing all the time, is she using the square that doesn't hold it's shape and needs twice as much area, or is she using a triangle? Quickly! [Response: Triangle!] If you go out of this room saying "squaring" ever again, humanity is all through!

[STANDING OVATION, ENCORE]